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Sampling Episode Report Holland America Oosterdam Sampling Episode 6506

Executive Summary

March 2006

EXECUTIVE SUMMARY

Sampling Episode Report for Holland America Oosterdam

This Sampling Episode Report describes the sampling and analysis activities to characterize wastewater (graywater and sewage) generated and discharged by the cruise vessel Holland America Oosterdam while in Alaska waters. This sampling took place from September 18 through September 23, 2004, under the direction of the U.S. Environmental Protection Agency (EPA). The sampling program is part of EPA's data collection effort to evaluate whether to develop wastewater discharge standards for cruise vessels, under 33 USC 1901 Note, for cruise vessels authorized to carry 500 or more passengers for hire when operating in the waters of the Alexander Archipelago or the navigable waters of the United States within the State of Alaska or within the Kachemak Bay National Estuarine Research Reserve. EPA will use information from the sampling of this vessel and three other cruise ships in Alaska to characterize wastewater generated and discharged by large cruise vessels with advanced wastewater treatment systems.

EPA selected the Holland America Oosterdam to characterize the performance of two ROCHEM UF Systeme GmbH wastewater treatment systems. The ROCHEM LPRO treatment system, which is used to treat accommodations and laundry wastewater onboard the Oosterdam, is an advanced wastewater treatment system that uses low pressure reverse osmosis followed by ultraviolet (UV) disinfection. The ROCHEM Bio-Filt® treatment system, which is used to treat sewage, galley wastewater, and membrane concentrate generated by the ROCHEM graywater treatment system onboard the Oosterdam, is an advanced wastewater treatment system that uses aerobic biological oxidation followed by ultrafiltration and UV disinfection. Samples were collected of various wastewater sources (accommodations, laundry, galley, and food pulper wastewater), influents to the treatment systems, influents to the UV disinfection components of the treatment systems, effluents from the treatment systems, source water, wastewater treatment residuals (screening solids and wastewater biosludge), and incinerator ash. Wastewater source samples were collected for a single 24-hour sampling period, while samples of the influents to and effluents from the treatment systems were collected for five consecutive 24-hour sampling periods.

Strap-on ultrasonic flow meters were installed near the sampling locations for accommodations wastewater, influents to treatment, effluents from treatment, and combined effluent discharge to collect flow data and, in some cases, to trigger automatic sampling machines.

Various sample collection methods (composite by flow, composite by time, grab, and grab composite) were used depending on the sampling point and the analyte. Tested analytes include pathogen indicators (fecal coliform, *E. coli*, enterococci), classical pollutants, total and dissolved metals, volatile and semivolatile organics, pesticides, polychlorinated biphenyls, and dioxins and furans. Not all samples were analyzed for all target analytes.

Accommodations wastewater contained the greatest number of analytes detected at the highest concentrations among graywater sources, most notably *E. coli*, enterococci, and most metals. Food pulper wastewater contained relatively few analytes detected at the highest concentrations among graywater sources; however, it showed the highest concentrations for several analytes commonly used to measure wastewater strength: biochemical oxygen demand (BOD₅), chemical oxygen demand (COD), and total organic carbon (TOC). Galley and laundry wastewater samples showed the highest concentrations for only 15 and 7 analytes, respectively.

The influent to the ROCHEM graywater treatment system contained key analytes, such as pathogen indicators, BOD₅, COD, and total suspended solids (TSS), at concentrations similar to those in typical domestic wastewater, even though this system does not treat any sewage. Of the 54 metal analytes tested for, 26 were detected in every influent to graywater treatment system sample. Among the 201 target analytes for volatile and semivolatile organics and pesticides, only 4 were detected in any influent to graywater treatment samples, most at concentrations close to their detection limits.

Because of water conservation measures onboard cruise ships (such as vacuum toilets), the influent to the ROCHEM sewage/graywater treatment system contained key analytes such as pathogen indicators, BOD₅, COD, and TSS at concentrations much higher than those in typical domestic wastewater. Of the 54 metals analytes tested for, 32 were detected in every

influent to sewage/graywater sample. Among the 360 target analytes for volatile and semivolatile organics, pesticides, and polychlorinated biphenyls, 20 were detected in Oosterdam influent to sewage/graywater treatment samples, most at concentrations close to their detection limits.

The ROCHEM graywater treatment system successfully removed almost all pathogen indicators (>99%) and most classical pollutants, metals, and organics. Fecal coliform was detected in 2 of the 15 effluent graywater treatment samples, enterococci was not detected in any effluent samples, and *E. coli* was detected in 1 of 15 effluent samples. The graywater treatment system removed most BOD₅ (80%), COD (85%), and TOC (70%), and removed settleable residue and TSS to below detectable levels. The graywater system reduced total Kjeldahl nitrogen (TKN), which measures both ammonia and organic forms of nitrogen by 76%, and total phosphorus by 90%, while nitrate/nitrite levels remained relatively unchanged. The graywater treatment system was highly efficient at removing particulate metals, and removed dissolved metals at an average of 52%. The graywater treatment system did not significantly reduce volatile and semivolatile organics.

The ROCHEM sewage/graywater treatment system successfully removed almost all pathogen indicators (>99%) and most classical pollutants, metals, and organics. Fecal coliform was not detected in any of the 15 effluent sewage/graywater treatment samples, enterococci was detected in 4 of 15 effluent samples, and *E. coli* was detected in 1 of 15 effluent samples. The sewage/graywater treatment systems removed almost all BOD₅ (>99%), COD (95%), and TOC (86%), and removed settleable residue and TSS to below detectable levels. The sewage/graywater treatment systems reduced total Kjeldahl nitrogen (TKN), which measures both ammonia and organic forms of nitrogen by 70%, and total phosphorus by 41%, while nitrate/nitrite levels remained relatively unchanged. The sewage/graywater system was highly efficient at removing particulate metals, and removed dissolved metals at an average of 40%. The sewage/graywater treatment system removed most of the volatile and semivolatile organics to concentrations below detection levels.

The ROCHEM graywater treatment system generates two types of residuals: screening solids (from a vibratory screen filter at the beginning of the treatment system) and spent bag filters (used for pretreatment prior to reverse osmosis). Screening solids are collected manually and disposed of in the incinerator system for discharge outside of 12 nm from shore. Spent bag filters are shredded and incinerated onboard. The ROCHEM sewage/graywater treatment system also generates two types of residuals: screening solids (from a vibratory screen filter at the beginning of the treatment system) and waste biosludge (excess biological mass from the treatment system's bioreactors). The screening solids and biosludge are pumped to a double-bottom holding tank for overboard discharge outside of 12 nm from shore. Most of the analytes detected in these residual wastes were also detected in the influent to the treatment system. For many analytes, concentrations in the screening solids and waste biosludge exceeded those in the influent to treatment, suggesting that these analytes are removed from the system in these waste streams.

On average, each person generated 31 gallons of untreated accommodations and laundry wastewater and 23 gallons of untreated sewage, galley wastewater, and membrane concentrate per day. Average combined discharge from the graywater and sewage/graywater treatment systems was 45 gallons per person per day.